

TITLE: **Electrostatically Enhanced Barrier Filter Collection**

PI: John Erjavec

STUDENTS: Nathan Kadrmas, Ryan Knutson

INSTITUTION: University of North Dakota
Department of Chemical Engineering, Box 7101
Grand Forks, ND 58202-7101
(701) 777-4244 FAX: (701) 777-3773
e-mail: john_erjavec@mail.und.nodak.edu

RESEARCHERS: Michael D. Mann
Department of Chemical Engineering, Box 7101
Grand Forks, ND 58202-7101

Michael L. Swanson
University of North Dakota
Energy and Environmental Research Center, Box 9018
Grand Forks, ND 58202-9018

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ABSTRACT

OBJECTIVE

This research is being undertaken collaboratively by the University of North Dakota's Department of Chemical Engineering and Energy and Environmental Research Center.

The objective of the current project is to develop a highly reliable advanced hybrid particulate collector that can be used with integrated gasification combined cycle (IGCC) electric generation processes. The collector must meet the most stringent turbine requirements and emission standards and must operate at temperatures above 1500°F and pressures up to 150 psig. It is also important the collector be useable with all U.S. coals, be compatible with various sorbent injection schemes for sulfur and alkali control, and that it can be integrated into a variety of configurations for both pressurized gasification and combustion.

The collector being proposed is a new concept in particulate control called **electrostatically enhanced barrier filter collection** (EBFC). This concept combines electrostatic precipitation (ESP) with candle filters in a single unit. The technology has been recently proven for atmospheric applications, but needs to be tested at high temperatures and pressures. The expected synergy obtained by combining the two control technologies into a single system should actually reduce filter system capital and operating costs and make the system more reliable. More specifically, the ESP is expected to significantly reduce candle filter load and also to limit ash reentrainment, allowing for full recovery of baseline pressure drop during backpulsing of the filters.

Three major tasks have been defined:

1. Design and construction of the EBFC – The bench-scale testing utilizes an existing continuous fluid-bed reactor (CFBR) and hot-gas filter vessel which can handle a gas flow up to 30 scfm at 1550°F and 150 psig. This task involves designing and constructing the EBFC with one centrally located candle filter surrounded by a circular wire high-voltage cage. The vessel wall is grounded and will serve as the collecting electrode.
2. Experimental Testing – The testing will be conducted in five steps: a) shakedown, b) screening to determine variables important to ESP performance, c) screening to determine variables important to overall system performance, d) follow-up response surface experiments to optimize overall system performance, and e) long-term proof of concept.
3. Conceptual Design for Full-Scale EBFC – Based upon the results from the proposed work, the conceptual layout for a EBFC will be drafted. This layout will include the spacing between the candles, electrode, and plate, and the placement of them in a filter vessel. Preliminary capital and operating costs will be determined, along with the parasitic power required for the ESP portion of the EBFC. The conceptual design will be based on a 100-MW IGCC system.

ACCOMPLISHMENTS TO DATE

Task 1 is complete. This involved calculation of the ESP cage wire diameter for proper corona, and design and construction of the EBFC system. This task took longer than expected, primarily because the ceramic insulators used in the system could not be machined in-house.

Task 2, Phases (a) and (b) are complete. The shakedown tests encountered a number of problems that had to be remedied. The two main problems were: (1) The feed through wire to supply the high voltage to the electrode cage had to be totally insulated to prevent arcing to the pipe wall. Therefore, the tiny gap between the ceramic insulator shielding the wire and the ceramic part of the feed through plug had to be filled with ceramic paste. (2) The conductive particulate was found to quickly coat all insulators and short out the ESP. Purges for the feed through electrode and the vertical insulators for the electrode cage were found to be critical. When purges were installed, coating was no longer a problem. In addition, arcing was found to disrupt the computer data acquisition and control system. This was remedied by isolating the computer and the computer power supply from the rest of the system. The ESP performance tests primarily centered on developing sufficient corona for the ESP to function. High temperature was found to give a much smaller voltage window for corona to occur, but sufficient for the ESP to function. The gas composition was found to be a critical factor. Pure nitrogen was not usable as a test gas, and nitrogen plus water vapor was also found to be unsatisfactory. However, when oxygen or carbon dioxide was added to the test gas, corona was able to be established. If CO and hydrogen were also added, corona was about the same, so it was decided to go with a simpler mixture for test purposes (for economic and safety reasons).

Task 2, Phase (c) is ready to begin. There have been some advances in the design of the low temperature, atmospheric pressure unit that is undergoing full scale testing. The design of the EBFC will probably be modified to include some of those enhancements.

SIGNIFICANCE TO FOSSIL ENERGY PROGRAMS

Integrated gasification combined cycle offers the potential for very high efficiency (over 50%) and clean electric generation. In order to reach that high efficiency, a method to clean the gas of particulate matter (as well as other pollutants) needs to be developed that can be used at high temperatures. This EBFC concept offers significant improvements in collection of particulates over existing technologies and it is also fully compatible with the technology for control of alkali and sulfur with sorbents. In the worst case, the cost of the EBFC is expected to be competitive with existing technology, but it is expected to provide far superior operability.

PLANS FOR THE COMING YEAR

The goal for the next performance period is to complete Task 2 (Phases (c) and (d)) will be done, which are the optimization of the overall system performance by running a statistically designed set of experiments. Also, Task 3 should be completed, which is the conceptual design of the full scale EBFC.

ARTICLES, PRESENTATIONS, AND STUDENT SUPPORT

ARTICLES

There have been no articles published or submitted for publication at this time, since there have been no experimental results generated yet. However, the expectation is that this work will result in at least two peer reviewed publications. It is also hoped that some of the design concepts can be patented, and that the technology can be transferred to the private sector for implementation and commercialization.

CONFERENCE PRESENTATIONS

There have been no presentations of this work at conferences. Again, the expectation is that this work will be of great interest to the power industry, and will be publicized and presented at two or more conferences next year.

STUDENTS SUPPORTED UNDER THIS GRANT

Nathan Kadrmas, graduate student in chemical engineering (MS), University of North Dakota
Ryan Knutson, graduate student in chemical engineering (MS), University of North Dakota